

Final Report

**Inspection and Preparation of HVAC Systems
in Army Facilities for Recommissioning**

Project Number

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Construction Engineering Research Lab

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1. Objectives: The objectives of this work are to define minimum requirements necessary to allow recommissioning of HVAC systems, and identify and evaluate the suitability of commercial off-the-shelf HVAC test instruments for use by DPW personnel.
2. Major Requirements: Task 1. Develop a standard inspection procedure to determine if the HVAC system is ready for recommissioning.
3. Recommissioning is the process of recalibrating and adjusting HVAC sensors, controllers, and air and water balancing devices, in order to return the system to its original operating condition specified in the most recent construction documents. In order to accomplish this task, the basic HVAC components must be in operational order without major air or water leaks. Since most buildings on Army bases are served by a central chilled water and steam plant, inspection of chillers and boilers is not included in the inspection procedure. Having copies of the latest construction drawings, including as-built control drawings, can significantly reduce the time required for building inspection. The basic inspection procedure is as follows.
 - a. Main Mechanical Room. The equipment typically located in the main mechanical room include the steam converter (hot water generator), condensate receiver and pumps, hot water circulating pump, chilled water circulating pump, and the control air compressor. These devices must all be inspected to confirm that they are in operational condition and that there are no major water or air leaks. Steam control valves and traps should be carefully inspected since these are prone to malfunction. Pumps and motors should be checked for noisy operation which might indicate faulty bearings. The filter-drier on the control air system should be checked for proper operation to insure that the control air is free of moisture and oil.
 - b. Air Distribution System. The ductwork, especially the flexible connections, should be inspected for major leaks. Air flow readings should be taken at each supply air diffuser and the total measured air flow compared with the design air flow. If the measured air flow is significantly lower the design air flow, but no leaks are found, there may be a partial blockage of the air flow that could result from clogged filters or coils.
 - c. Air Handling Unit. The supply air fan should be inspected for corrosion, missing fan blades, and improper alignment. The static pressure across the fan and across each coil should insure proper air flow. Inlet vane dampers and static pressure controllers should be checked for proper operation. Economizer dampers should be checked for proper operation. Condensate drain pans should be inspected and replaced if they are found to be rusted out or leaking. The trap on the condensate drain line should be checked and the condensate drained piping should be free-flowing.
 - d. Control System. As previously stated, control air that is free of moisture and oil is critical. The main air supply line should be removed from several thermostats at various locations throughout the building. Evidence of moisture or oil in the supply

air indicates a serious problem that must be remedied before any recommissioning process could begin. Thermostats are probably the most abused component of a control system, yet they are critical for the acceptable environmental control. If the thermostats are new, a few should be checked for proper operation. If the thermostats have been in service for more than five years or if there is evidence of abuse, they should all be inspected to confirm that they are not clogged and that changing the set point changes to the branch output.

Control Panels. The pneumatic controls in the air handling unit control panels should be inspected to confirm that tubing is connected and that no components have been by-passed. The pressures indicated on the pressure gauges in the panel should be observed and if the readings are all zero, the control panel is probably inoperative.

Damper Actuators. The linkages between the dampers and the damper actuators should be inspected to proper connection and alignment. If the linkages are disconnected, the dampers may be binding or the control system may be inoperative.

Hot Water/Chilled Water Control Valves. Pneumatically controlled valves should be checked for leaks and they should be inspected for proper operation.

Energy Management System. Unless the building is occupied 24 hours per day, there is probably a time clock or EMCS system which controls that HVAC system during periods when the building is unoccupied. This system should be inspected to determine if it is operational.

4. **Critical Operating Components.** The integrity and proper operation of the following systems is required before a recommissioning effort should be initiated.
 - a. The hot water and chilled water distribution system, including pumps and control valves.
 - b. The control air system, including the filter-drier.
 - c. The supply air and return air duct system.
 - d. The supply fan, cooling and heating coils, and condensate drain system.
 - e. The temperature control system, including the thermostats, chilled water and hot water control valves, and the temperature control dampers and actuators.
 - f. EMCS system.
5. **Basic Control System.** Most HVAC control systems have been designed using complex sensing, feedback and control strategies to maximize energy efficiency. These sophisticated systems require regular maintenance by a highly skilled technician or the energy performance of the system quickly deteriorates. After several years of improper maintenance, including the by-passing of inoperative components, many control systems are abandoned and manual methods of temperature control are adopted. These manual methods do not produce acceptable indoor comfort conditions and they are very energy inefficient. For older (>15 years), smaller (<100,000 s.f.) buildings, replacement/ renovation of the existing

sophisticated control system with a basic control system is recommended. The following control features characterize a basic control system.

- a. Room Temperature Control. The thermostats and temperature control components (valves or dampers) must be operational.
 - b. Hot Water Generator with Outside Air Reset Controller.
 - c. Chilled Water and Hot Water Coil Control Valves at each Air Handling Unit.
 - d. A simple time clock with a winter-summer switch (or EMCS system) to:
 - (1) activate the chilled water or hot water coil depending on the season, and
 - (2) deactivate the cooling or heating coil at night (when the building is unoccupied).
6. Applying the Inspection Procedures for a Building at Ft. Bragg. This inspection procedure was applied to a Company Administrative and Supply building (#6715) at Ft. Bragg. Many HVAC system deficiencies were uncovered and a contractor was hired to correct these problems and to replace the control system with a basic control system. Occupant comfort and energy use were monitored before and after the contractor completed the repairs.
- a. Inspection results-System Deficiencies. Inspection of the HVAC system revealed that the thermostats were inoperative, the sophisticated hot deck/cold deck discriminator controllers were inoperative, the damper linkages to the temperature control dampers and the economizer dampers had been disconnected, and the EMCS system was inoperative, and the hot water controller was also inoperative. There was also a major air leak at the flexible connection at one of the air handling units.
 - b. Initial Comfort Conditions. Temperature and humidity data was taken at several locations in the building. Since the HVAC systems were operating in the full cooling mode, 24 hours per day, 7 days per week, the office areas were over-cooled in the early mornings with the temperatures dropping below 65 °F. The building occupants compensated for this situation by leaving the outside doors open to warm the space. Some occupants also used electric heaters beneath their desks.
 - c. Initial Energy Use. Chilled water supply and return water temperatures were monitored and the daily energy use in the building was approximately 7 million BTUs.
 - d. Contractor Repairs. The contractor replaced the thermostats and reconnected the damper actuators, thus restoring temperature control to the offices. The sophisticated hot/cold deck controllers were removed and replaced by a summer-winter switch which activated/deactivated the chilled water and hot water valves. The EMCS system was also replaced with a 24-hour time clock which shut down cooling or heating after hours. The air handling units and the chilled water, hot water circulating pumps continued to operate 24 hours per day. The contractor also replaced the hot water generator outside air reset controller.
 - e. Final Comfort Conditions. Office temperatures were controlled at the setpoint of the thermostats after the temperature control system was retrofitted.

- f. Final Energy Use. Energy use in the building decreased by approximately 40% as a result of installing the time clock to close the chilled water coil control valve from 6:00 pm until 6:00 am. Although retrofitting the room thermostats and the temperature control system improved energy efficiency, the inaccuracies of the energy measurement system made it impossible to determine the energy impact of this retrofit. The payback for the retrofit was calculated to be 1.6 years.
7. Task 2: Evaluate the suitability of HVAC test instruments for use by DPW personnel. Attached is a list of the equipment, including costs, that was purchased as part of this project.
- a. Alnor, Shortridge and TSI flow hoods. At the time of this report, the Alnor and Shortridge hoods had been received. The Alnor compact hood is much smaller and easier to carry from building to building. It has an analog output which is less precise than the Shortridge hood which has a digital output. For recommissioning constant air volume systems in older buildings the Alnor hood is preferable.
 - b. Solomat multi-function meters vs. individual test instruments. The Solomat IAQ Surveyor is the ideal instrument for investigating indoor air quality conditions. Its four-function head simultaneously reports (and logs) temperature, humidity, carbon dioxide and carbon monoxide. A separate probe can be used to measure particulates in the air in three size ranges. A velometer probe can be used to measure air flow rates. The Solomat unit comes with calibration gases and its accuracy is better than the individual sensors. However, the four-function probe is large and not suitable for insertion in ducts to measure supply and return air conditions. For this important task individual test meters are better.
 - c. Architectural Energy Microdataloggers vs. HOBO sensors/loggers. The HOBO four-function sensor/loggers were used on this project for monitoring room temperature, humidity, outside air temperature, and chilled water temperature. Except for monitoring chilled water, the HOBOs performed extremely well. Monitoring chilled water temperatures is problematic because, while Pete's plug probes are available for both the HOBOs and the AE microdataloggers, there typically are no Pete's plugs on the chilled water return piping. Since the return water temperature varies much more than the supply water temperature, accurate measurements are critical. Since the chilled water return piping typically has a dial thermometer well, a probe that can be screwed into the well is needed. Two probes were ordered for evaluation as part of this project, but they are back ordered at this time. The accuracy of the HOBO sensors/loggers does not appear to be as good as the AE microdataloggers, but the HOBOs are much more compact and less expensive.
 - d. In addition to supply and return water temperatures, measuring water flow rates is critical. Since nearly all chilled water and hot water systems have orifice or venturi-type flow meters and many others have circuit-setter valves, an accurate differential pressure meter is needed.